Space Weather Technical Forecast

Issued on Sunday, 02 June 2024 at 00:30 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Moderate to High activity with further M-class or X-class flares likely. CMEs from late 01 June currently awaiting analysis.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with two X-class flares observed, X1.4 at 01/0848 UTC and X1.0 at 01/1836 UTC, both from AR3697 in the southeast disc. Despite being much reduced from its previous incarnation as Ex-AR3664 on the last rotation, this remains a moderately sized region, with slight increase in penumbral area observed during the period. A delta spot persists within its leading region, although this appears to be decaying somewhat. A new small delta spot formed in the trailing region of the same group. This is one of nine numbered regions on the visible disc. Previously notable region AR3691, located in the northwest continued to simplify, breaking into smaller component spots. Of the remaining groups on the disc, some modest growth was observed in AR3695 and AR3699 in the northwest, meanwhile AR3700 in the southwest and AR3701 in the southeast emerged as maturing, but still rather simple bipolar groups.

The X1.0 flare of AR3697 at 01/1836 UTC was followed by a sympathetic, long period M7.3 flare from the same region, peaking at 01/1940 UTC. Both flares appear to have resulted in CMEs, with LASCO and STEREO A imagery still backfilling at the time of writing. Type II and IV Radio Emissions were observed with the second of these flares. A full-halo CME was observed from Earth's frame of reference from the first flare, with the second flare resulting in a partial halo CME, apparently more displaced towards the east. As more imagery becomes available these features will be analysed and modelled for input into forthcoming forecasts. Additionally there are a number of filaments on the disc, including two large filaments across the southern hemisphere that will be monitored for any potential lift-offs.

Solar Wind / Geomagnetic Activity: Observations by ACE at L1 showed speeds persisting at background at 320-360 km/s, with density largely below background, but with brief periods of nearer average values, most notably after 01/0936 UTC. These density changes could perhaps be related to a very slight glance from the CME of the X1.4 flare on 29 May, however this is somewhat uncertain. Interplanetary Magnetic Field, Bt, was weak, 1-5nT with the north-south component, Bz, also varying weakly. Phi angle was generally negative (towards the Sun), but briefly rotated to be slightly positive (away from the Sun) after 01/0936 UTC. Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux at GOES18 remained at background levels with no solar radiation storms occurring. High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels with the associated 24-hour fluence well below the Active threshold. Observed fluence at 02/0000 UTC was 2.98e6 integrated pfu.

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Four-Day Space Weather Forecast Summary

Solar Activity: High to Moderate activity is forecast with further occasional M-class or X-class flares expected, mainly from AR3697 in the southeast.

Solar Wind / Geomagnetic Activity: A weak CME from the C7.5 flare of AR3698 and subsequent nearby coronal dimming on 31 May is expected either late day 1 or early day 2 (02-03 Jun), although confidence is low with the strength of any arrival due to the faint and weak nature of the CME. Analysis of the double CME event late on 01 Jun is still pending. Otherwise background winds are likely to persist, with a chance of becoming slightly enhanced for a time between days 1 and 2 (02-03 Jun) with any onset of the fast wind of small CH41/+, however this is also low confidence.

Geomagnetic activity is forecast to be mainly Quiet, but increasing to Unsettled to Active with any fast wind onset day 1 (02 Jun) or CME arrival day 1-2 (02-03 Jun). These bring a slight chance of G1 Minor Storm intervals, and a very slight risk is maintained on days 3 and 4 (04-05 Jun), given the recent activity on the disc and the potential for further CMEs. Please note that the forecast for days 3 and 4 (04 and 05 Jun) does not currently include the pending analysis of the double CME event from late 01 Jun. As such probabilities for these days are likely to be updated in the next bulletin.

Energetic Particles / Solar Radiation: High energy proton flux is expected to persist at background, but with a slight but increasing chance of rising above the S1/Minor Storm threshold given any further notable flares. High energy electron flux is forecast to persist at background, with the associated 24 hour fluence forecast to remain below the Active threshold.

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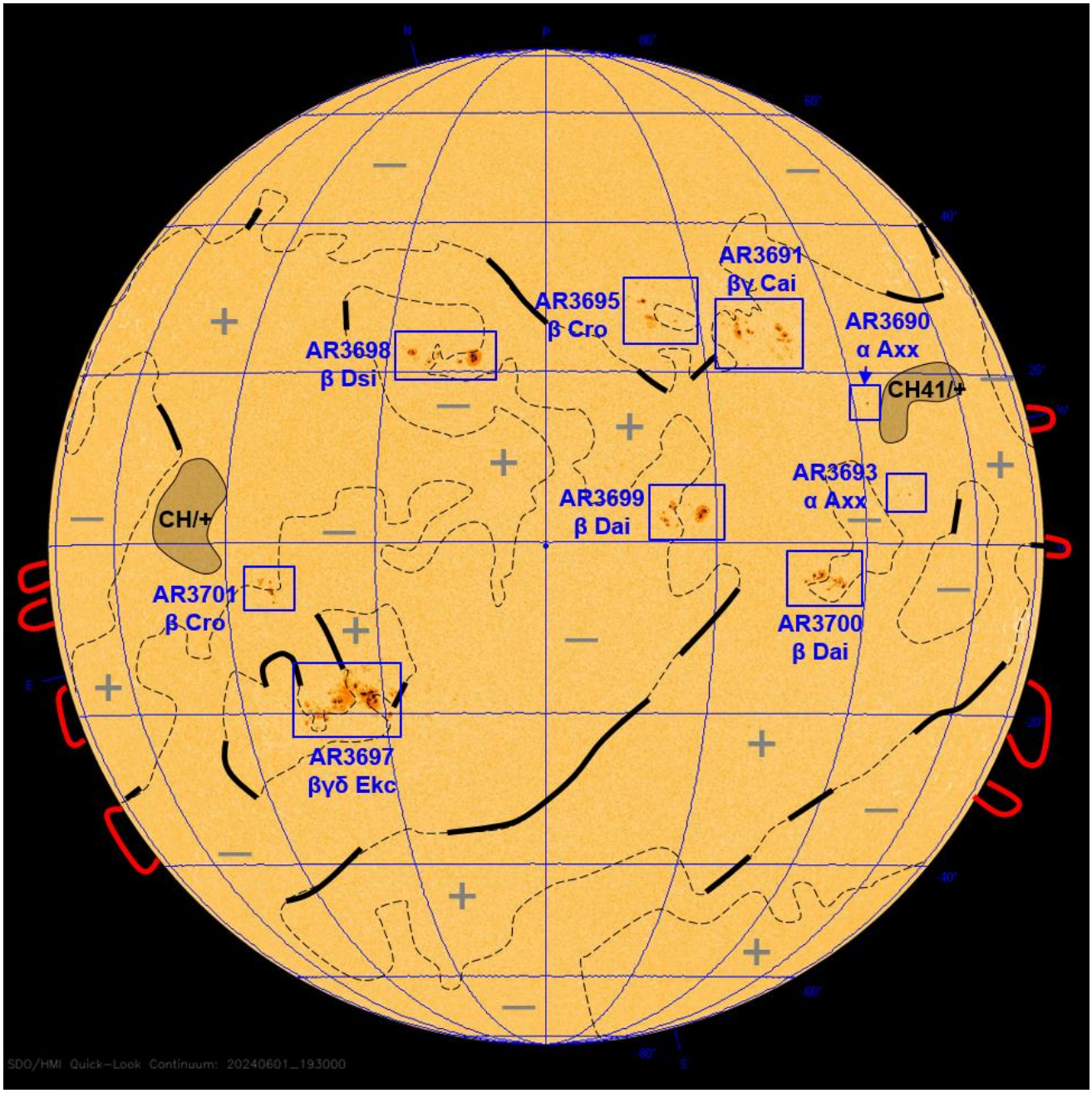
Figure 1. Solar Analysis Valid 01/1930 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A faint partial halo CME was observed on 30 May, perhaps from the C7.5 flare of AR3698 and subsequent nearby coronal dimming around 30/0500 UTC. This is very low confidence, due to the indistinct nature of the CME on imagery, but brings a likely weak arrival late on day 1 or early day 2 (02-03 Jun).

The X1.0 flare of AR3697 at 01/1836 UTC was followed by a sympathetic, long period M7.3 flare from the same region, peaking at 01/1940 UTC. Both flares appear to have resulted in CMEs, with LASCO and STEREO A imagery still backfilling at the time of writing. Type II and IV Radio Emissions were observed with the second of these flares. A full-halo CME was observed from Earth's frame of reference from the first flare, with the second flare resulting in a partial halo CME, apparently more displaced towards the east. As more imagery becomes available these features will be analysed and modelled for input into forthcoming forecasts.

Current background solar winds may see a very weak enhancement from CH41/+ on day 1 (02 Jun), perhaps becoming slightly elevated before likely easing to background again during day 2 or 3 (03 or 04 Jun). This feature is currently overestimated in current MOSWOC Enlil output, leading to reduced confidence in any potential connection, but also in the arrival times of forecast Earth-directed CMEs.

There are also a number of large filaments currently on the Earth-facing disc. These will be closely monitored for any potential Earth-directed eruptions should any of these features lift-off of the solar surface.

Geomagnetic activity is forecast to be mainly Quiet, but increasing to Unsettled to Active with any fast wind onset day 1 (02 Jun) or CME arrival day 1-2 (02-03 Jun). These bring a slight chance of G1 Minor Storm intervals, and a very slight risk is maintained on days 3 and 4 (04-05 Jun), given the recent activity on the disc and the potential for further CMEs. Please note that the forecast for days 3 and 4 (04 and 05 Jun) does not currently include the pending analysis of the double CME event from late 01 Jun. As such probabilities for these days are likely to be updated in the next bulletin.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/1205	Partial	C7.5 flare and coronal dimming	NE	710 km/s	02/2000 UTC +/- 12 hours	Low confidence and faint in imagery

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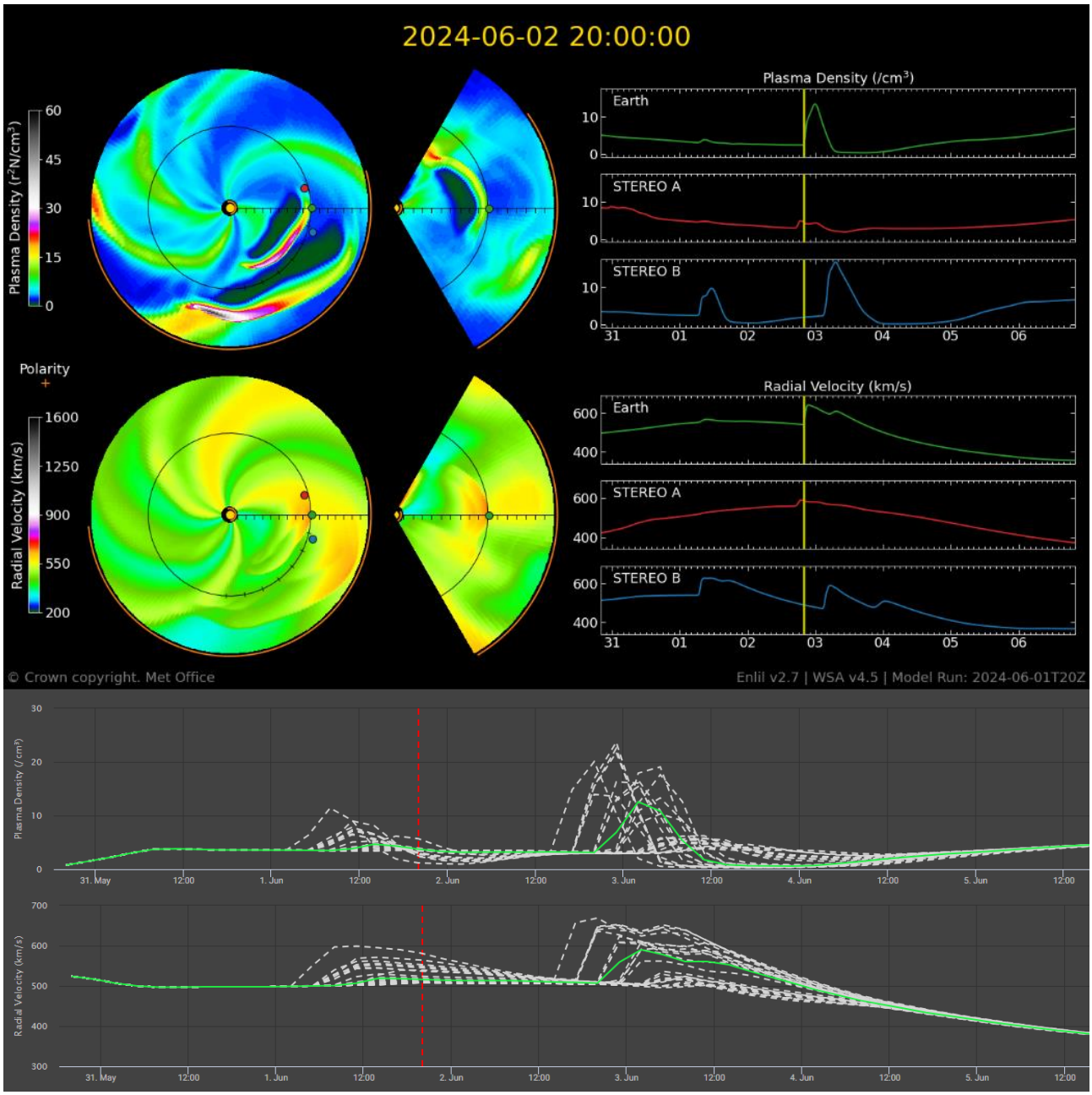
Figure 2: Latest Enlil output and Ensemble forecast



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Radio Blackouts - X-Ray Flares:

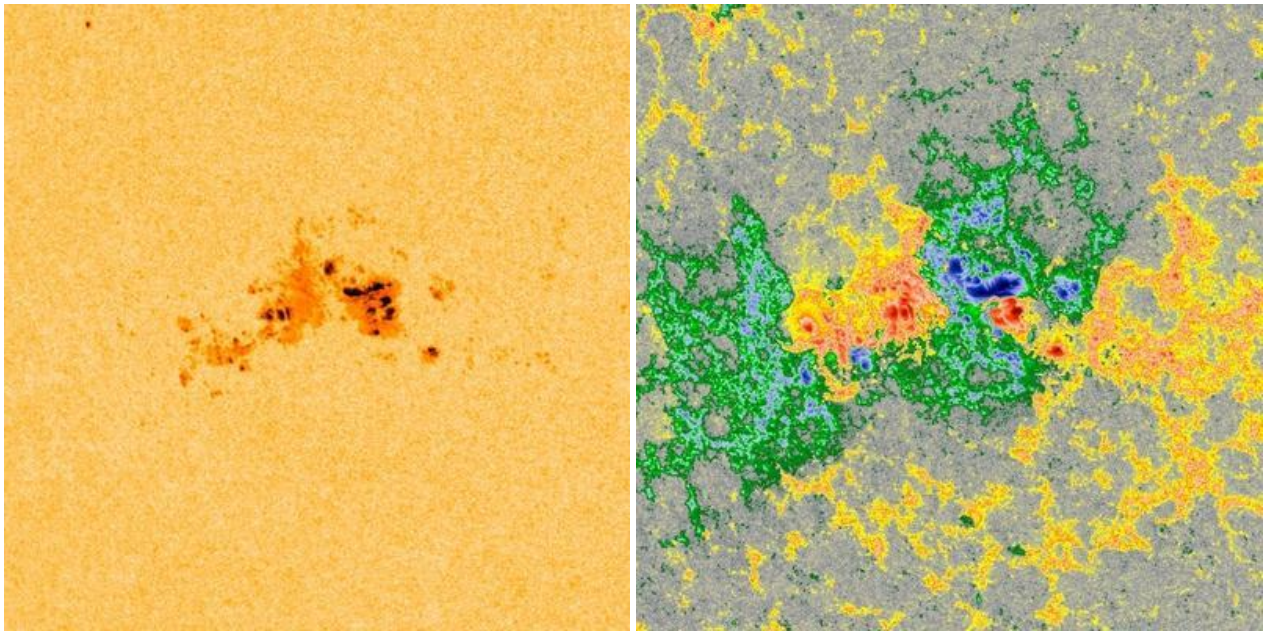
Solar activity is currently High, and expected to remain Moderate to High through the period, with the potential for occasional M or X-class flares, predominately from AR3697.

There are nine numbered sunspot regions on the disc. The majority of the activity is associated with AR3697, which persists as a moderately sized and complex spot on the southeast disc. While reduced in size and complexity compared to the last rotation (as AR3664), this region has now produced five X-class flares since being observable on the east limb. The region has seen slight growth in areal extent, and there is a strong delta spot within its leader, albeit rather small and with some signs of this feature decaying. Additionally, a small delta spot has formed in the trailing portion of the group. While both persist there will remain the potential for X-class flares, and an isolated flare exceeding X10 (R4 Blackout) cannot be completely ruled out.

AR3691 in the northwest continues to show a gradual declining trend, having lost its previous delta configuration. AR3698 in the northeast and AR3699 in the northwest have matured into typical bipolar configurations, with some spreading and consolidation of their component spots. AR3699 in the southeast also indicates a relatively simple bipolar configuration, but has shown some small ongoing growth, with penumbral extent increasing. AR3700 in the southwest and AR3701 in the southeast emerged as maturing, but still rather simple bipolar groups.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	75	70	60
Very Active	R3 to R5 X Class	Yes	40	40	30	25

Figure 3: Latest HMI imagery of AR3697



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Solar Radiation Storms - (High Energy Protons):

GOES-18 high energy proton flux is currently at background, with no response observed from the numerous X-flares of AR3697 on 31 May and 01 Jun. This region, however, continues to have the potential for stronger X-flares, and also has a continuously improving location for any such flares to eject Earth-directed high energy protons. Despite this improving location, the confidence in the longevity of the flare risk from the region does slightly fall through the period. These two factors balance to give an overall slight chance of proton flux enhancement occurring and reaching the S1 Minor Storm threshold. Given the potential for stronger flares, it also cannot be completely ruled out that any such proton storm could exceed the strong threshold (S3 Strong radiation storm).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux, as observed by GOES-16, is expected to persist at mainly background, with no notable sources of potential enhancement currently anticipated. The associated 24 hour electron fluence is expected to remain well below the Active level, as supported by MOSWOC REFM, which is currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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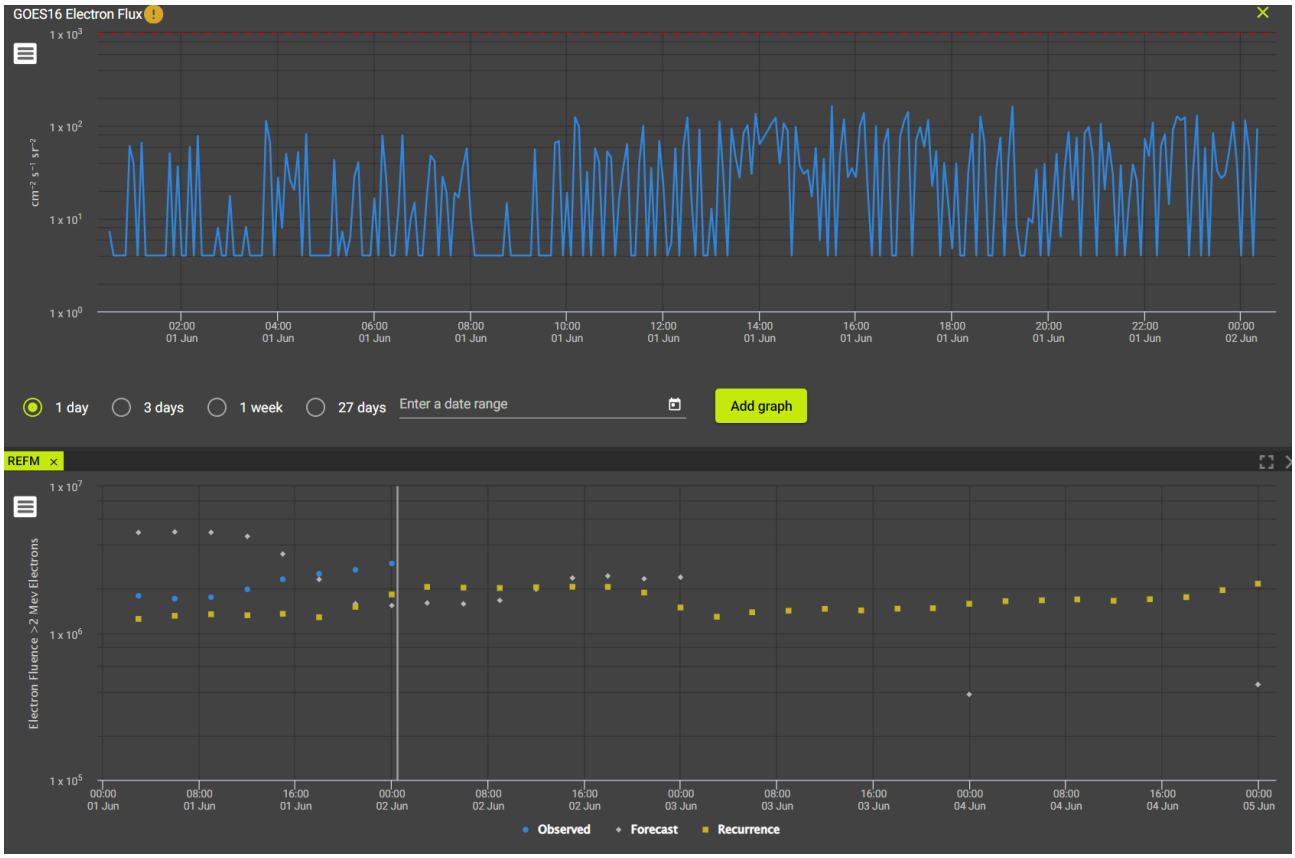
Figure 4: GOES16 >2MeV Electron Flux and REFM forecast with Recurrence



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